FOREST SERVICE • U. S. DEPARTMENT OF AGRICULTURE

1962 Annual Report

NORTHERN FOREST EXPERIMENT STATION
JUNEAU • ALASKA
RICHARD M. HURD • DIRECTOR

1962 - Annual Report
Northern Forest Experiment Station

foreword

A major objective was accomplished this year with the completion of the field plot work for the Interior forest survey. The last plot was in the Lake Clark region (60° 3' N., 153° 51' W.) and sampled a white spruce stand having trees up to 54 feet tall and 120 years old. Compilation, analysis, and report writing must be finished before Alaska's first forest inventory is actually completed.

Another step forward has been the start and partial completion of an intensive re-examination of all research project programs. In some instances where work is getting under way, as the Forest Fire and Forest Insect projects, the principal effort was to chart a course of action leading to specific objectives. In the older projects there has been a summing up--a critical evaluation of what work should and should not be continued--and a look into the future to discern how best we can apply our efforts.

We have been strengthening and sharpening our ability to improve our research efforts. Three of our men were away on graduate study for all or part of the 1962-63 academic year. Progress was made in the construction of our Forestry Sciences Laboratory on the University of Alaska campus. Construction completion is anticipated by summer 1963.

Richard M. Hurd

contents

soil and water

● <u>Soil and water research</u> for the past thirteen years has been concerned with how logging affects salmon stream physical characteristics such as maximum and minimum flows, water temperature, amounts of suspended sediment, logging debris, and natural debris accumulation and movement, and changes in streambed configuration. The objectives are now expanding to include identifying facts basic to coordinated stream management and land management practices to improve streams for salmon spawning; and to determining factors and processes involved in soil erosion and mass movements of soil and measures for minimizing them.

● <u>Log jams</u> formed naturally are common in coastal Alaska salmon streams. Forces, such as streambank cutting and strong winds, put trees into the streams. If the debris becomes concentrated in the channel a log jam is formed. Such jams can be unstable and move with changes in streamflow, or they can remain in place for many years with little change. Frequently we find a gradual increase of material in the jams.

Logging can contribute to log jam formation by adding debris such as cull logs, tree tops, and branches to the stream. However, timber sale policies are intended to avoid unnatural sources of debris in the stream.

It is reasonable to suppose that log jams do not remain in place indefinitely, and it is a logical speculation that periods of unusually high streamflows cause major changes in log jams and stream channels. Such a period of high streamflows occurred on our study streams in 1961. Aerial photos shown on the next two pages were taken from a helicopter before and after the high flows and illustrate the magnitude of changes that can occur.

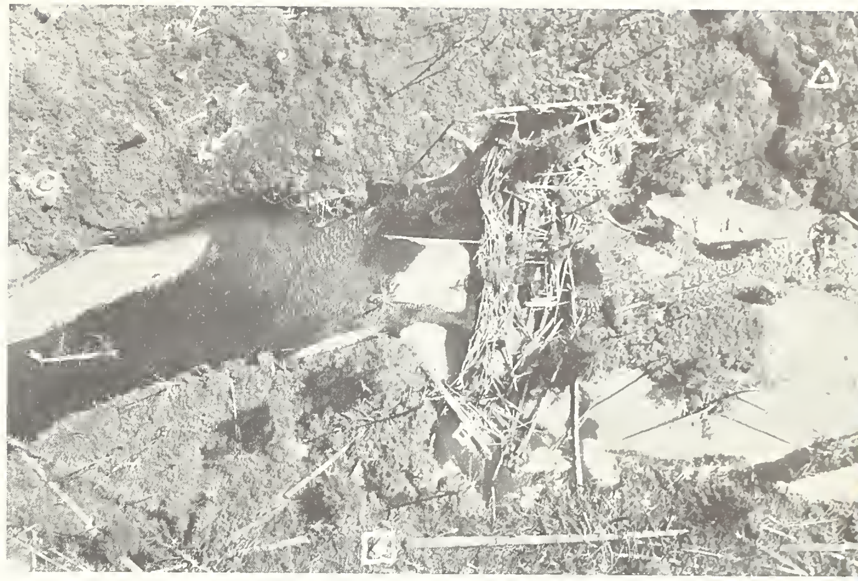
1961

1962

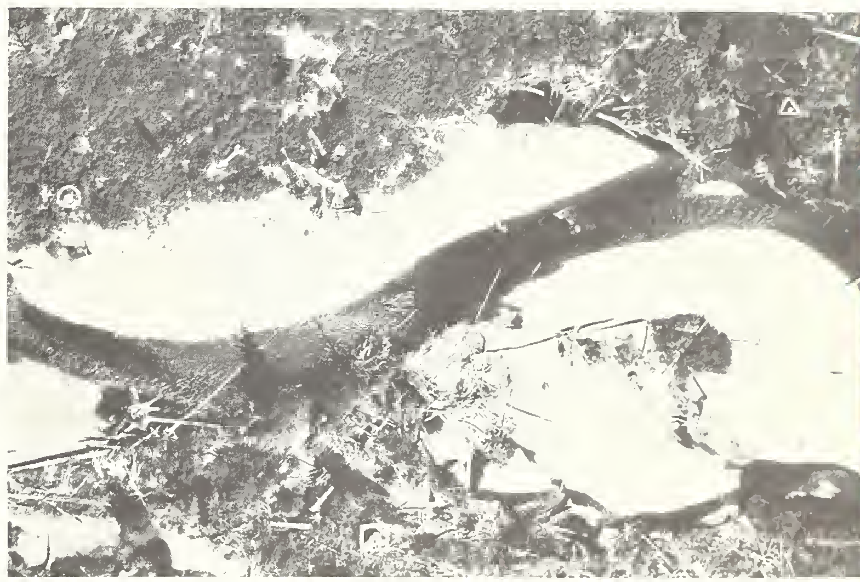
These "before and after" photos show that gravel bars, islands, and riffles present in 1961 were reshaped by high October streamflows. This action is probably periodic with years of high peak streamflows. Such flows tend to occur in the fall when significant losses of salmon eggs or larvae may occur due to gravel shifting. These photos were taken about a year apart. The symbols indicate orientation points common to both photos. A four-foot square panel serving as a photo scale and reference point is visible near the lower right corner of the 1961 photo.

These photos of another area on the same stream shown on the previous page illustrate a different log jam history. The 1961 view shows a natural jam that had been in place several years. When the felled timber shown was skidded out and hauled away (soon after the photo was taken) the larger materials in the log jam were also removed. High streamflows of fall 1961 reshaped the formerly braided channel into a riffle area. The symbols show orientation points common to both views.

1961



1962



While observations on log jams and the effects of peak streamflows began recently and on a modest scale, early indications are that stream channel debris and high streamflows increase streambed instability. Instability results in a number of effects on stream channels, the final results of which can be mortality of salmon eggs, larvae, and fry.

- <u>Effects of log jams</u> on a streambed were measured in a year with unusually high streamflows and through the use of two "hand-made" log jams. This research was in cooperation with the Fisheries Research Institute of the University of Washington.

This is the site of one of the hand-made log jams. The natural debris shown was already in place. The site was mapped and streambed elevations were surveyed. Streambed gravels were sampled to determine composition by size classes of materials and the dissolved oxygen content of the water flowing through the gravels. June 1961.

This is the hand-made log jam that was constructed on the site shown above to simulate a naturally formed jam. The jam is about 50 feet long. July 1961.

High streamflows in October of 1961 washed out the log jam and formed new streambed conditions. May 1962.

The log jams caused the streambed gravel to move, a stream condition which fisheries biologists believe is undesirable for salmon egg development. Movement of the streambed gravels crushes, buries, or flushes out salmon eggs, larvae, and fry. At the same time, some benefits accrued from the log jams. There was less fine material in the streambed gravel. This increases waterflow through the gravel which results in more dissolved oxygen in the water--an important factor favoring salmon egg development. Nevertheless, we believe the undesirable gravel movements caused by the log jams outweighed the desirable features.

An aim of forest land management is to improve streambed stability during and after logging. Practical improvement and maintenance of desirable spawning stream conditions will involve a complex balance of interacting, complementing, and conflicting land and stream factors.

forest insects

● <u>The objectives of insect research</u> in the coastal forests of Alaska are threefold: (1) To measure the direct and indirect impact of insects on the forest resources. (2) To determine the biology and ecology of those insect species having a significant impact on these resources. (3) To develop biologically and economically sound methods of controlling the important injurious species or ways of preventing serious damage.

● High populations of the black-headed budworm defoliated millions of acres of western hemlock and Sitka spruce from 1948 to 1955. Large volumes of dead timber now occur in the areas previously defoliated. Destructive outbreaks could occur again at any time so we have concentrated our research on the budworm and an associated insect defoliator, the hemlock sawfly. The sawfly prefers old needles while the budworm prefers needles of the current year's growth. Feeding together they can cause complete needle loss and tree death. High populations of the hemlock sawfly usually coincide with high budworm numbers.

A spruce-hemlock forest on Admiralty Island that has been defoliated by the black-headed budworm. Note the dead trees which appear lighter than those still living. The older, less vigorous trees may be so severely weakened by defoliation they die or become more susceptible to diseases.

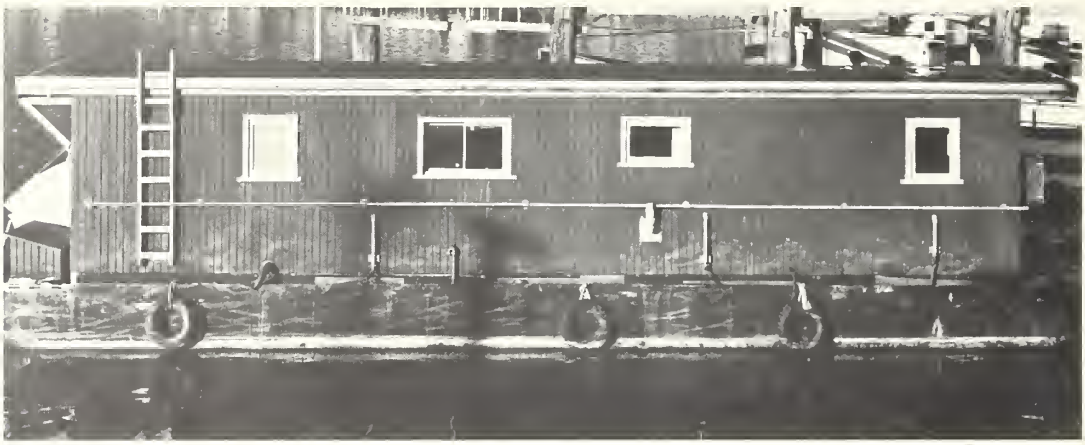
● Larvae of the black-headed budworm and the hemlock sawfly feed on needles of both Sitka spruce and western hemlock. The budworm is a wasteful feeder in that many needles are clipped off at the base and not consumed. This results in much more defoliation than that caused by feeding alone.

Both the budworm and the sawfly overwinter in the egg stage, hatch in May, feed on needles during the summer, pupate and emerge as adults in early fall when eggs are laid and the life cycle is completed. Both insects are common inhabitants of our hemlock-spruce forests.

Black-headed budworm larva...........pupa..........adult

Larva...............cocoon...............and adults (male upper) of the hemlock sawfly.

● <u>To facilitate our insect investigations</u> we have equipped a wanigan (floating camp) with laboratory and crew quarters. The wanigan consists of a steel barge 52' 5" long and 15' 5" wide upon which was built a wooden frame structure for laboratory and living quarters.



This wanigan is a self-contained unit with a generator, two-way radio, propane gas utilities, and fresh water storage. In addition, the compact...

... laboratory contains equipment necessary for effective field work.

These facilities give us the necessary mobility to study forest insect populations throughout southeast Alaska.

● At times, when conditions are favorable for survival, the number of black-headed budworms increases rapidly and an outbreak is in progress. What causes these population eruptions? What are the effects of various predators, parasites, and disease organisms? To help answer such questions we have started an investigation at Limestone Inlet which is shown here.

The objectives of the current Limestone Inlet investigation are to (1) determine what percentage of the budworm population dies at various stages of its life cycle--egg, larva, pupa, and adult and (2) determine the reasons for death. Knowledge of the factors causing mortality may help us devise ways of preventing future outbreaks.

Our work at Limestone Inlet began with the overwintering egg stage. The egg and the hemlock leaf shown here are magnified 24 times. At Limestone Inlet a total of 600 eggs--20 eggs on 30 trees--are being examined monthly to record loss or death and possible causes. An additional 1,400 eggs attached to needles were collected for laboratory investigations involving the effect three temperature levels and different periods of exposure to these temperatures have upon survival and hatching.

forest inventory

● Field work for interior Alaska's first timber inventory has been completed. Much preparation and study took place, however, before the field work was finished. As a start, about 11,000 miles of aerial photography were taken. Infrared film with a minus blue filter was used. The photographs were taken at a scale of 1:5000 with flight lines 30 miles apart. Each 9-inch square photograph covers less than one square mile of land area. About 37,000 photographs were obtained.

In the office, a one-half-acre plot was marked off near the center of each photo, then classified as to land type, such as commercial forest, non-commercial forest, non-forest land, or water. All forest plots were studied carefully with a stereoscope to determine the kind, size, and density of the timber.

An added step before actual selection of the field plots was to have an observer refly 110 miles of the lines that had been photographed. By flying at about 500 feet above each plot location, we could verify and correct much of the work that had been done on the photos. From the plots studied in these 110 miles, 150 classified as forest land were randomly selected for field study and measurement.

To accomplish this extensive field inventory, our 2-man crews traveled more than 300 hours in light planes, over 150 hours in helicopters, made numerous trips by boat, and covered several thousand miles by car. Upon reaching the plot, the location was described. Then the crew marked off the same one-half acre that had been studied on the photograph. Next, they proceeded to record the vital statistics of each tree. They determined species, and measured total height and diameter at breast height (DBH). The condition of the tree was recorded, and the amount and quality of usable wood determined. Age of the stand and rate of growth were obtained from wood cores extracted from selected sample trees.

These statistics were brought back to the office and placed on IBM cards. Data obtained from the air observations and from the stereoscopic study of photographs are also on IBM cards. By mechanical comparison of related cards, adjustments of area and volume estimates can be made. This compilation, analysis, and interpretation of data remains before a report can be written and published.

However, part of what we found can be told in photographs, such as some that follow.

● White spruce

White spruce is the predominant and most important commercial species in the Interior. The best stands of spruce, as well as of all other trees, were found along the well drained river bottoms of the Susitna, Copper, Tanana, Yukon, and Kuskokwim Rivers.

This stand near Fairbanks averages about 10,000 board feet per acre. The trees are 95 feet tall and about 100 years old; lower stems are well pruned and clear. Diameters at breast height range from about 10 to 24 inches in these stands. This is a good stand for interior Alaska but not unusual. White spruce stands mature at 100 to 150 years of age if not damaged or destroyed by fire. Local sawmill operators and settlers select the best white spruce trees from these stands and use them for lumber, house logs, mine timbers, and general construction. Present use is limited by local needs and a lack of processing into finished wood products. In 1961, only 4 million board feet of logs, of all species, were used by 37 active Interior sawmills. Increased use can be expected as new wood-using industries are established locally.

These white spruce logs produced from stands on the Aniak River are being made into house logs at a mill near Aniak. The logs have been partially squared by sawing three sides. This shows the bark being removed from the fourth side. Sometimes house logs are turned on a lathe to make them uniformly round. Another method is to saw two sides, leaving round sides exposed inside and outside the house when constructed. Still others are hand peeled and used in the shape the tree grew.

● <u>Paper birch</u>

Several varieties of paper birch grow throughout the Interior in pure and in mixed stands. Most common tree associates are white and black spruce, and quaking aspen. Good sites produce stands of birch sawtimber 70 to 80 feet tall with diameters ranging from 12 to 24 inches at breast height. Commercial use of these stands is just beginning.

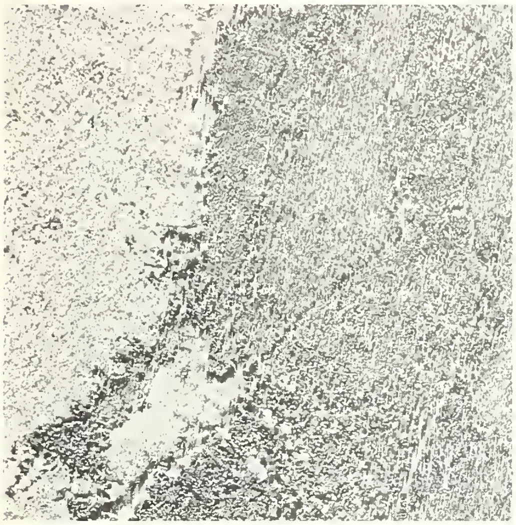
This birch sawtimber stand along the Chena Hot Springs Road will produce two to three 16-foot logs per tree with diameters 12 to 20 inches. However, such stands as this are not common or extensive.

Trees of good quality were found in some stands, particularly in the Susitna River valley. But in general, the birch of Alaska is too small to produce high quality logs for lumber and veneer; or becomes very defective by the time it reaches 15 inches DBH and larger.

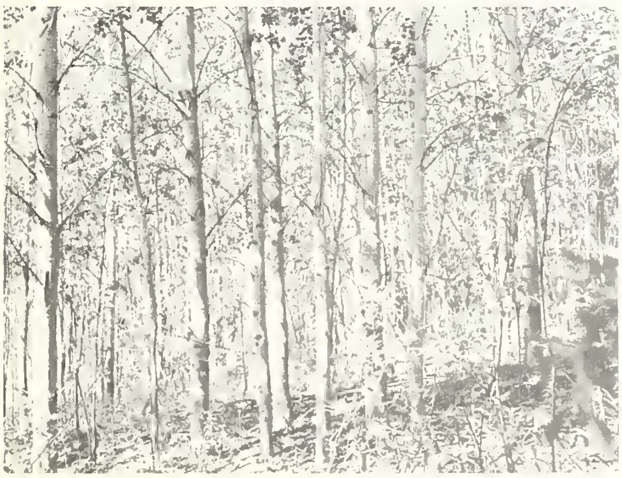
This stand of birch saplings along the Steese Highway near Circle is too dense. Stands such as this are not likely to produce mature trees of commercial value unless thinned. White spruce usually invades and dominates these sites before birch reaches sawtimber size of 11 inches DBH.

● Quaking aspen

Aspen grows as pure stands and also in mixture with birch and spruce. After a fire, many forest areas seed back to dense stands of aspen.



This aerial view shows a dense stand of aspen (the white-crowned trees) adjacent to a stand of black spruce. All this area was once in black spruce but a fire more than 30 years ago killed the spruce, and aspen seeded in. The area shown here in black spruce is called non-commercial forest land because the trees grow so slowly and will not produce sawtimber (trees 9 inches DBH and larger for softwoods). The aspen stand, on the other hand, is producing about 25 cubic feet of wood per acre annually, and is classed as commercial forest land. The aspen stand is about 30 years old and 45-50 feet tall.

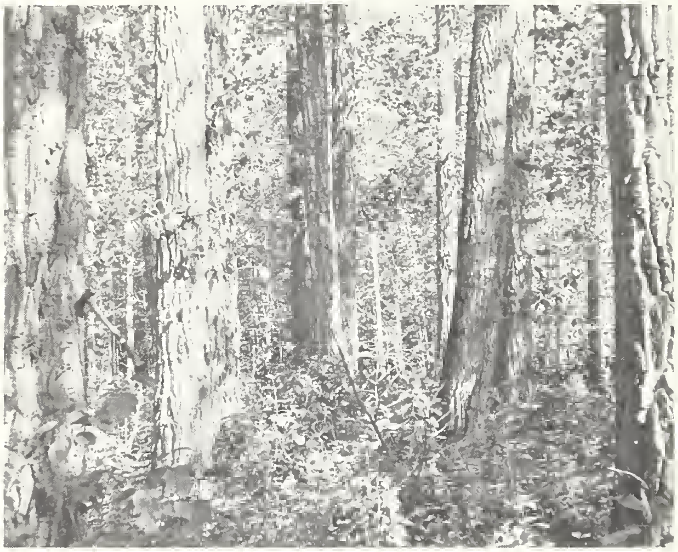


Although aspen occasionally reaches sawtimber size (11.0 inches DBH and larger for hardwoods), the stand shown here is more typical. Stems are 3-4 inches DBH, 40-50 feet tall, and 30 years old.

Aspen matures in 60-80 years--much earlier than most other trees. After that it decays and dies rapidly. Because of this rather short life span, aspen normally does not grow to be larger than 10 to 14 inches DBH and is useful mostly as pulpwood. Very little aspen is used in Alaska at this time, and none as pulpwood.

- Balsam poplar

This tree is found mainly along the streams and on the better sites. It is fast growing, and stands of relatively high volume (20-40 thousand board feet per acre or more) are found. One plot near Galena on the Yukon River had individual trees that reached a height of 60 feet in 22 years.



The taller trees in this Matanuska River stand are 20 to 28 inches DBH, 95 feet tall, and 170 to 235 years old. Stands such as this can produce high quality logs for factory grade lumber and veneer, but are not now being used for these purposes. Some cottonwood is being shipped to Japan from southeast Alaska but none from the Interior.

These balsam poplar logs are to be sawn into lumber at a small sawmill near Palmer. The logs range from about 12 to more than 20 inches in diameter and are cut in various lengths --usually 8 to 16 feet long. The lumber is used green, both rough and surfaced, in local construction. Balsam poplar lumber is suitable for some purposes, but it is weak, has poor nail-holding ability, and is not resistant to decay. This species is more suitable for veneer, plywood, and pulp.

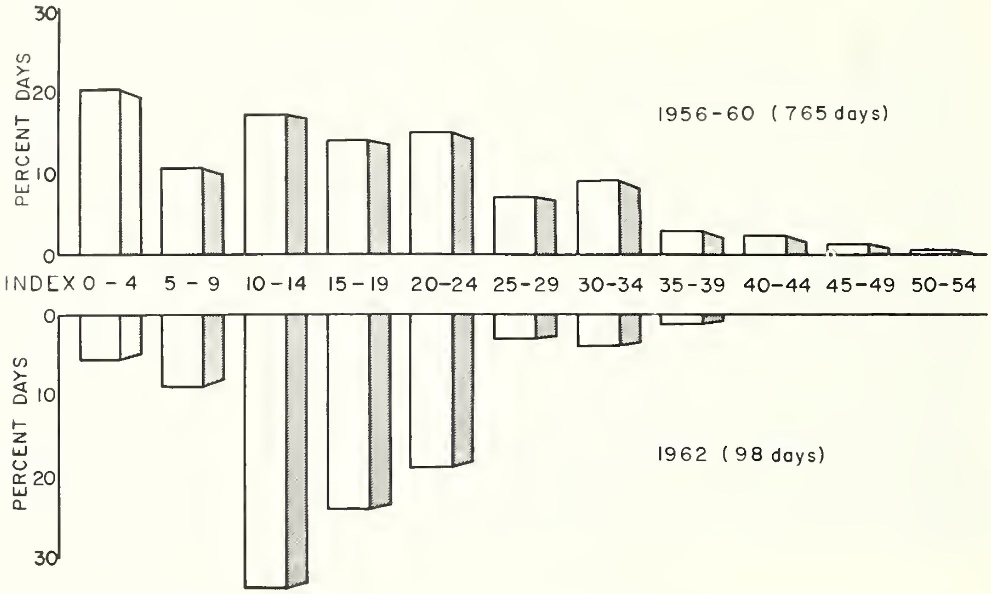
forest fire

● The first full year of forest fire research was used to evaluate the magnitude of interior Alaska's wildfire problem. Since 1940, over 20 million acres of forest, tundra, and grassland have been damaged by fire. In the past ten years, the average annual loss due to fire, in terms of timber, recreation, wildlife habitat, and watershed has been estimated to exceed 2.5 million dollars. Although increased effort to control wildfire and reduce fire loss has been made during the last few years, very little research has been done. It is our intent to study significant characteristics of fuel, weather, and topography, and find out how they influence fire. We also wish to determine more effective ways for controlling wildfire.

● Weather is a major factor in determining a season's fire activity. Weather components such as wind, temperature, relative humidity, and precipitation influence the amount of damage fires may cause.

These components, as well as an index to fuel moisture, can be measured at portable fire weather stations like this one developed by the Forest Service. This station can be set up quickly near a fire to provide weather data used in predicting the behavior of the fire.

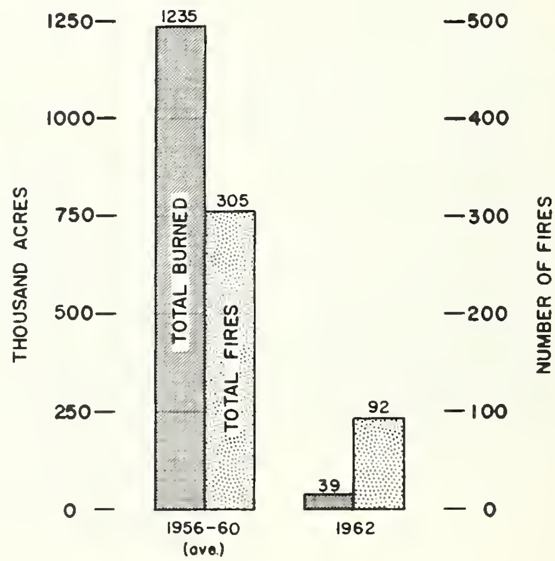
Daily fire weather data are used also in combination with various fuel factors to determine fire danger. Relative severity of fire danger is often described by a numerical scale or index with 0 index representing the lowest, and 100 index the highest possible forest fire danger. Fire danger was determined from weather data collected at Fairbanks during the fire season in 1956-60 and in 1962. The percentage of days reaching a specific index were plotted for the "average" 1956-60 fire season and for 1962. The results...



... show that, in the 1956-60 average, there occurred a greater percentage of days with severe fire danger than in 1962.

Another comparison was made between the average 1956-60 fire season and 1962 fire season by using the number of acres burned and the number of fires.

The apparent relation of fire weather to fire activity points out the need for developing an accurate method of describing and predicting fire danger if adequate control of wildfire in Alaska is to be realized.



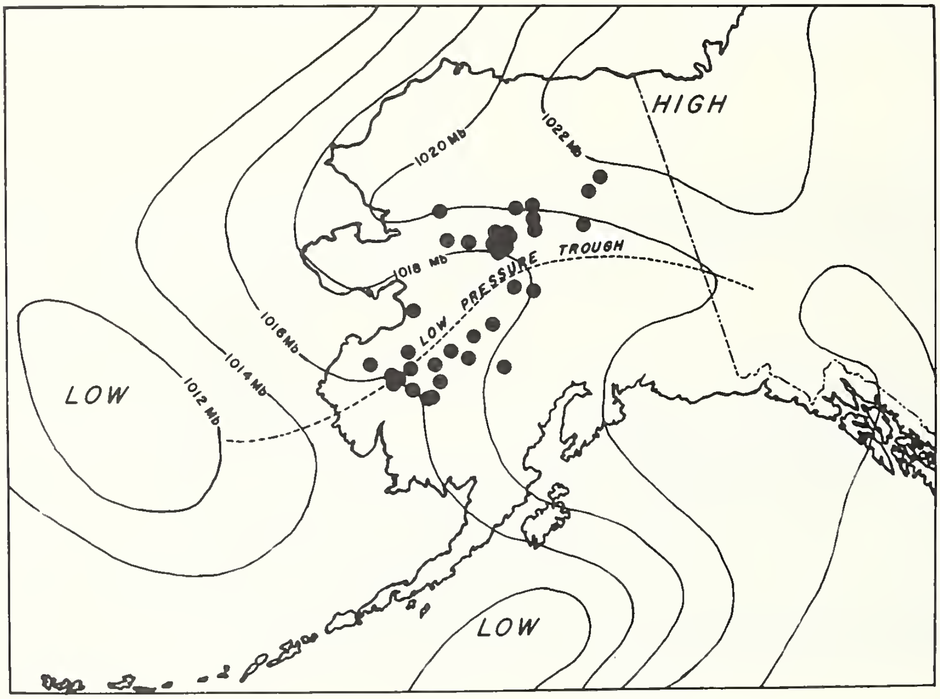
● <u>Lightning</u> is presumed to cause about one-quarter of Alaska's forest fires. Because these lightning fires often occur in remote areas and escape prompt detection, they account for about three-quarters of the burned area. Very few people have actually observed lightning starting a fire. Since lightning occurs with thunderstorms, we became interested in the development patterns, location, movement, and method of forecasting thunderstorms.

In cooperation with the Weather Bureau and Bureau of Land Management, a detection aircraft was dispatched to areas where thunderstorms were forecasted to occur. The location, development stage, height, and base were recorded for each storm (or cell) observed.

This modified World War II P-51 "Mustang," chartered by the Bureau of Land Management, was used for detecting forest fires and verifying thunderstorm forecasts in remote areas where surface observations are not available. The aircraft has an estimated range of 1,500 miles at 300 mph.

The first thunderstorms we observed in the Interior basin occurred in early June near the Canadian border. The average height of the cells was 14,000 feet. Heavy rain and lightning accompanied all of these early storms.

During the peak of thunderstorm activity (July 1-18) it became evident that the one aircraft could not provide adequate surveillance of all areas where storms were forecasted. No definitive results were obtained. For those storms that were observed, however, the average height of cells was over 25,000 feet. Precipitation accompanying each storm varied from light to heavy; lightning was recorded for less than ten percent of the observed storms. There was no significant difference in appearance between storms producing heavy rain and those producing light rain. The pattern of occurrence for all storms seemed to be closely related to atmospheric pressure patterns ...



... as seen here where lines are used to connect points having equal barometric pressure measured in millibars (Mb). The above pressure pattern was determined from Weather Bureau surface observations taken at 1200 hours, Greenwich mean time, on July 18, 1962. The low pressure trough extending northeasterly from the Bering Sea through the Interior basin shows an association with 36 fires reported during July 18-19 as lightning caused.

This is one of the lightning caused fires started during the July 18-19 thunderstorm activity. The fire was 200 miles from the nearest fire weather station and, consequently, the fuel and weather conditions at the scene were known in only a very general way. Control required six days, 10,000 man-hours, and 0.71 inches of rain; 2,300 acres of spruce, birch, aspen, and associated plants were burned.

trees

coastal forests

● Research on coastal forest timber is aimed at discovering facts about the germination, establishment, and growth of important tree species, mainly western hemlock and Sitka spruce. These facts are then used to determine how and where to grow the optimum quantity and quality of timber for pulpwood, sawlogs, and other products.

Re-establishment or regeneration of the forest after harvesting has been one of our primary interests. In addition to quantity of seed produced, distance of seed dispersal into harvested areas, and losses due to seed-eating small mammals, the establishment of the new forest is also affected by the condition of the ground (seedbed) upon which the seed falls. A test of fire as a means of improving seedbed condition was completed this year.

● Prescribed burning, controlled fire set for a particular management purpose, was tried on those areas where...

...concentrated logging debris...

...and dense brush patches are unfavorable seedbeds for starting the new forest. Thick layers of moss and decayed wood, characteristic of undisturbed areas, are favorable for germination but unfavorable for survival of young seedlings. This type of seedbed sometimes dries rapidly before seedlings are rooted in the moist mineral soil below and the seedlings die of drought. Drying of organic layers is more rapid in areas exposed by timber removal than in uncut forests.

Prescribed burning is a possible way of eliminating or reducing accumulations of logging debris, brush areas, and thick accumulations of organic material on the ground surface. The prescribed burn shown here was made on Prince of Wales Island in 1957 in one and one-half- to two-year-old logging debris. The fire was set following six rainless days to allow fuels to dry.

A fairly uniform but light burn resulted. Very little material over one-fourth inch in diameter was consumed...

... except in "hot spots" where debris was concentrated.

Blueberry brush growing in logging debris was burned back to stubs but the surface organic layer seldom was scorched to a depth greater than one-fourth inch.

About two weeks after the fire, plots were established in the burned and an adjacent unburned area and sown with western hemlock and Sitka spruce seed to compare seed germination and seedling survival on the two areas.

Also, survey lines were established to determine changes in development of brush and other vegetation.

Results.--Spruce germinated better than hemlock on burned seedbeds but the reverse was true on unburned seedbeds. Survival of spruce seedlings was equally good (near 50 percent) on both areas but hemlock survival was significantly better, 56 percent compared to 43 percent, on unburned areas. In addition to seeding the experimental plots, the entire area was seeded to both spruce and hemlock. This produced a good seedling stand with little difference between the burned and unburned areas.

Brush cover three years after burning was rapidly approaching the amount on a comparable unburned area. The amounts of cover were 7 and 16 percent the first year and 21 and 26 percent by the end of the third year. However, salmonberry became the dominant brush species on the burn. Blueberry was the dominant brush on the unburned area as it had been on the burned area before the fire. Salmonberry is a stronger competitor for the tree seedlings than is blueberry.

The intensity of this experimental burn made after six rainless days in 1-1/2- to 2-year-old logging debris was too light to markedly improve seedbed conditions for starting a new forest. However, with more information on fuel types, fuel moisture content, and weather relationships, fire may be a useful forest management tool. Its potential usefulness in coastal Alaska remains practically unexplored. Fire as a tool is of enough promise to warrant further investigation as a possible way of aiding prompt forest establishment on heavy slash areas and on potential brush areas like this...

... productive spruce flat on the Chickamin River logged in the early 1940's where tree reproduction is spotty in competition with a nearly complete cover of brush and grass.

● "Residuals" are another post-logging feature. "Residual" is a term that here refers to unmerchantable trees, usually western hemlock, surviving clear cutting. A five-year study was made to determine if such trees are generally a benefit or detriment in forest management. Residual trees usually are slow-growing, suppressed individuals in the stand before logging. Will they survive logging damage and winds, produce seed, respond in growth rate to release from competing neighbors, and will they eventually become merchantable?

Here are some fairly typical examples of residuals....

In the study, 55 percent of these trees had basal or trunk wounds, 30 percent had broken tops. Miscellaneous other defects affected from 1 to 5 percent of the trees. Only 23 percent of the trees studied had no serious injury or defect.

Slightly more than one-half of the trees in the study were living after five years. Twice during the study period the residuals bore moderate to heavy cone crops. Diameter growth increased from 0.36 inch in five years before logging to 1.08 inches in five years after logging. Height growth was negligible--only 1.1 feet in five years after logging. Thus, it appears unlikely that many residuals will become merchantable or be an important component of the new forest.

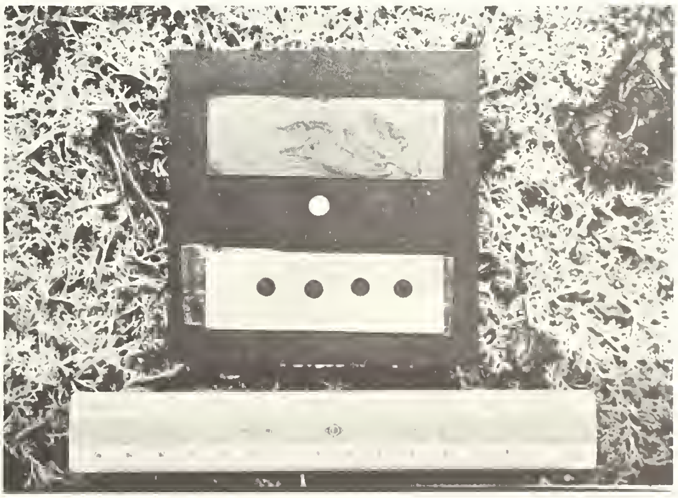
We believe that residuals will not be strong competition to the development of a new forest on clear-cut and high-lead-yarded areas--the common method of harvesting and logging timber in southeast Alaska. In those clear-cut areas where tractors were used to skid logs to a loading point, there were more residuals. However, these trees appear to have the same undesirable growth characteristics as those we studied. Because there were more residuals after tractor logging, they could pose a definite competitive threat for the development of the new forest. Felling or killing the more vigorous and potentially dominant residuals may be desirable unless there is strong evidence the seed from these trees is needed to start the new forest.

interior forests

● Regeneration of white spruce after fires and logging is one of the major problems facing those concerned with the management of the Interior forests. To more fully understand some of the fundamental processes involved in regeneration, we started exploratory studies in 1962. One of these was concerned with the distribution and abundance of pollen. Inadequate pollen to fertilize female spruce flowers can be one cause for low yields of good seed. Insufficient viable seed, in turn, bears directly upon the chances for successful regeneration of white spruce forests.

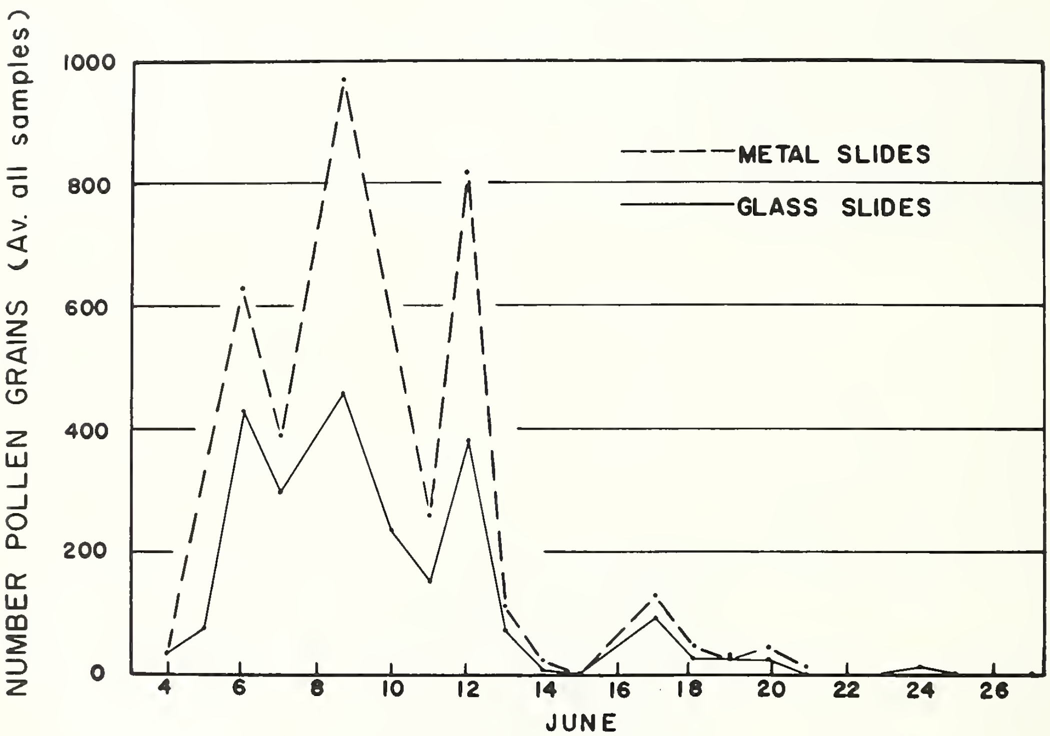
Techniques to determine pollen abundance and time of distribution were tested in a 50- to 70-year-old white spruce stand near College, Alaska. Seven sampling points were used. Three of these were in the spruce crowns about 40 feet above the ground, and the other four were on the ground within the spruce stand. Ground level sampling involves less apparatus and requires less time than sampling at crown height. However, crown level sampling seems the logical place since spruce female flowers are generally in the upper part of the crown. Hence, the reason for comparing pollen sampling at two heights.

Pollen was collected at the seven sampling points by using both a 1 x 3-inch glass slide with the top surface smeared with vaseline and an equal-sized metal slide with four one-quarter-inch holes, as shown in the photograph. Pollen grains falling into the holes were caught and held by "scotch" tape across the bottom of the slide. After a predetermined exposure period the slides were removed and pollen grains caught in the holes were counted with the aid of a microscope. An equal counting area on the glass slides was delineated by using an overlay with four one-quarter-inch holes. Certain advantages of the metal slides had been reported by others so we wished to test both kinds.



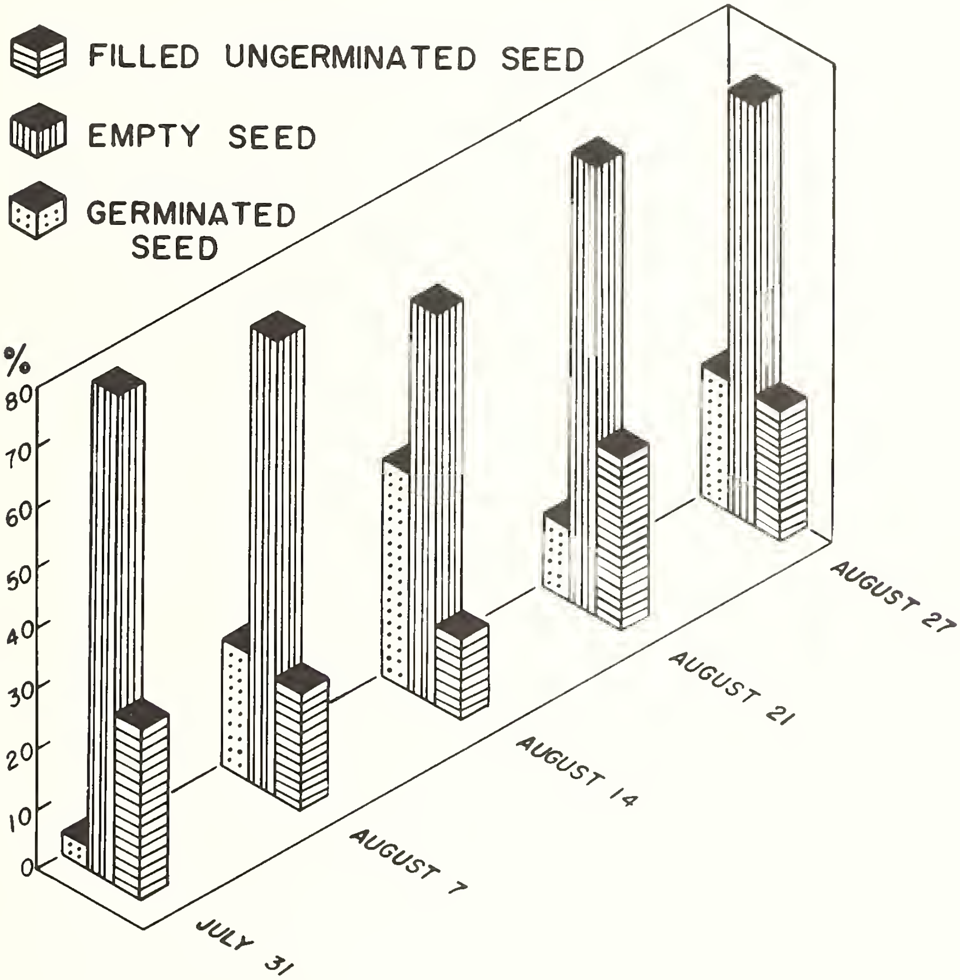
More pollen was caught by slides at tree crown level than by those slides at ground level. This was especially true between June 6 and 11 when large amounts were found on the slides at tree crown level. By June 14 pollen counts were low and remained at low levels until counts were discontinued on June 26. These tests lead us to prefer tree crown level sampling.

Both metal and glass slides recorded peak pollen amounts on the same days. Although the pollen count was not the same for both kinds of slides --more pollen on metal slides--the same trend was evident....



... The peak activity--June 6 through 12--was recorded by both metal and glass slides (the June 9 peak is an accumulation of 2 days). Pollen counts on the glass slides were faster and less variable than those for metal slides. Both features are distinct advantages.

Pollen abundance and quality, as well as receptivity of the female flowers at the time of pollen distribution, all can influence the amount of good seed produced. Perhaps one of these factors, or a combination of them, was responsible for the high percentage of empty or undeveloped seed found in cones collected between July 31 and August 27 in three white spruce stands in the Fairbanks area ....



... As seen in the diagram, the "empty" seeds accounted for 60 to almost 80 percent of the total seed found in the sample cones. "Germinated" seed is capable of producing a spruce seedling and, theoretically, could produce a mature tree although seedling mortality is thought to be high in Alaska's interior. "Filled ungerminated" seed is usually considered to be potentially capable of germinating but, for some reason(s), failed to do so in the tests.

publications

Miscellaneous Publications

1. Haack, Paul M.
   1962. Evaluating color, infrared, and panchromatic aerial photos for the forest inventory of interior Alaska. Photogrammetric Engin., 28(4): 592-598.

Technical Notes

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GPO 999683